
Chilliwack Forest District

Documentation of Analysis for Vegetation Resources Inventory Statistical Adjustment

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TERRESTRIAL INFORMATION BRANCH**



MARCH, 2002



EXECUTIVE SUMMARY

This report documents the Vegetation Resources Inventory (VRI) analysis that was completed for the Chilliwack Forest District VRI Ground Sample Inventory. The material presented in this report was made available for the current Timber Supply Review (TSR) and was developed in conjunction with staff from Ministry of Sustainable Resource Management, Terrestrial Information Branch, Vancouver Forest Region and Ministry of Forests, Timber Supply Branch and Vancouver Forest Region and Chilliwack Forest District.¹ Funding was largely provided by Interfor through Forest Renewal. Planning and analysis support was provided by J.S. Thrower and Associates Ltd. and Jahraus and Associates Ltd.

The report references and contains content from the previously developed "Chilliwack Forest District Vegetation Resources Inventory Ground sampling Plan, October 20th 1997" and the "Interfor Hope Logging IFPA VRI Sampling Plan for the Fraser TSA, Aug 20, 1999².

The objective of the original 1997 VRI ground sample plan was to sample the operable and inoperable Vegetated Treed (VT) portion of the Chilliwack Forest District³, excluding private lands, Parks and other legally recognized Protected Areas, TFLs, and woodlots in order to achieve a sampling error of 10% at the 90% level of probability for the ratio of net merchantable volume. The plan was revised in 1999 to focus sampling within the Interfor Hope IFPA and the remaining VT area of the TSA. In addition, a separate VRI ground sample study was completed within the Chilliwack River Landscape unit.

This analysis focused on the development of adjustment factors for height, age and volume to support the current timber supply analysis. The process used to derive these adjustments is interim (Fraser protocol) and may change in the future. In the "Fraser Protocol", the statistical adjustment of inventory attributes consists of a set of steps and assumptions used to develop and then apply adjustment factors to the VIF (Vegetation Inventory Files) file attributes of height and age and the volume predicted using VDYP version 6.0. The goal of the adjustment is to remove any overall bias in the inventory when compared against the VRI ground data for the attributes that are adjusted.

The steps in this adjustment process are :

1. Adjust height and age.
2. Based on the adjusted height and age, use VDYP to computed inventory volume (attribute - adjusted inventory volume)
3. Use the compiled ground volumes to then adjust the "attribute-adjusted" inventory volume.

The information contained in this report is "draft", however it is expected that this information will be used to adjust the VRI photo based inventory database files.

Sample polygons were largely selected over the entire target population using multiple pass ordered

¹ The material presented in this report may not be final values used in the upcoming timber supply review.

² Copy attached

³ The final analysis has reported a population that differs slightly from the original plan.

systematic (MPOS)⁴ sampling system. The inventory was implemented over a four year period resulting in the installation of 193 VRI sample clusters. NVAF sampling was also completed in this unit.

Based on a final timber supply analysis population of interest, defined as the operable, vegetated treed portion of the Interfor Hope IFPA, Chilliwack River landscape Unit (operable and inoperable) and the remaining operable VT area within the Chilliwack Forest District; age 29 yrs+ , using the net factoring and NVAF loss factor system, the *overall* impact of this study was to adjust the current VDYP estimated volumes by factors of 1.036, 0.847 and 0.930 respectively. The sampling error of the ratio of net merchantable volume for all stands > 29 years of age was estimated at 17% at the 95% level of probability.⁵

When the overall adjustments were applied to the VIF planning files for all operable, VT stands in the Chilliwack Forest District, greater than 60 years of age, an average net merchantable volume of 437 m³/ha ⁶was reported.. This overall value could be compared to the 425 m³/ha reported for a similar population in the last timber supply review.⁷

The total contract costs associated with this project are estimated at \$500,000.

⁴ Please contact the biometrician at TIB for more information regarding MPOS statistics.

⁵ At the request of MoF Timber Supply Branch probability levels are reported at the 95% level.

⁶ 17.5 cm+, close utilization, net merchantable volume (less decay waste and breakage using 1976 loss factors).

⁷ Figures reported from pg. 9 "Incorporation of the Inventory Audit in the Fraser TSA, Timber Supply Review, B.C. Ministry of Forests, Victoria, B.C., May 1997.

Table of Contents

EXECUTIVE SUMMARY	1
1. INTRODUCTION.....	4
1.1 BACKGROUND.....	4
1.2 SCOPE AND OBJECTIVES	5
2. METHODS.....	5
2.1 OVERVIEW OF STATISTICAL ADJUSTMENT	5
2.2 POPULATION FOR ADJUSTMENT.....	6
2.3 DATA SOURCES	7
2.4 DATA ISSUES RELATED TO THE ANALYSIS.....	8
2.5 DATA MATCHING.....	8
2.6 PRE-STRATIFICATION AND SUB-STRATIFICATION.....	9
2.7 MPOS FORMULAE USED TO COMPUTE ADJUSTMENT RATIOS AND SAMPLING ERROR.....	10
3. RESULTS AND DISCUSSION.....	10
3.1 AGE AND HEIGHT ADJUSTMENT.....	10
3.2 VOLUME ADJUSTMENT	11
3.3 OVERALL VOLUME IMPACT	12
4. APPENDIX A: GROUND AND INVENTORY DATA	14
5. APPENDIX B: DETAILED RESULTS	15
6. APPENDIX C: GRAPHICAL ADJUSTMENT RELATIONSHIPS.....	1

1. INTRODUCTION

1.1 Background

The Fraser TSA was pre-stratified into 3 main units for the establishment of the VRI ground samples:

- Chilliwack River Landscape unit (CRLU)
- IFPA portion of the TSA
- Non-IFPA portion of the TSA

With the exception of the CRLU (which was sampled in a single pass), samples for these units were selected using Multiple Pass Ordered Systematic sampling.

A portion of the area was missed in the initial sample selection and samples from these missed areas were selected subsequent to the initial sample selection.

Within the IFPA and the non-IFPA portion of the TSA, the area was further pre-stratified into operable and inoperable and a disproportionate number of samples were selected in these strata (80% of samples were selected in the operable area and 20% in the inoperable area). The desired number of samples selected in the operable and the inoperable areas were obtained by "artificially inflating" the areas of polygons in the operable stratum so that the ordered systematic sampling process would select a larger number of operable polygons.

Samples were chosen in 8 passes in the non-IFPA portion of the TSA and in 4 passes in the IFPA. The CRLU was comprised of a single pass. Each pass in the IFPA and the non-IFPA portion of the TSA included a mix of operable and inoperable samples. All samples in the CRLU were considered to be operable.

After the initial sample selection for each pass was completed, it was discovered that a number of mapsheets had been missed in the sample selection process. It was decided that estimates from the "missed area" samples would be combined with the non-missed area estimates (based on the relative areas of the missed vs. non-missed areas) in each of the analysis strata below⁸.

To simplify the development of adjustment factors the analysis followed the pre-stratification that was used in the sample selection. Hence the basic strata analyzed were:

- IFPA operable;

⁸ Treatment of the missed areas created significant discussion. Initially, the missed area samples were randomly allocated to existing passes. However, after discussions between Peter Ott, Vera Sit, Bill Warren and Sam Otukol it was decided to consider the missed area samples as separate "sub-strata" within each of the analysis strata (i.e. IFPA operable, IFPA inoperable, non-IFPA operable, non-IFPA inoperable & CRLU). Estimates from the missed areas were then combined with the non-missed area estimates based on combined ratio estimate formulae as provided by Peter Ott.

- IFPA inoperable;
- Non-IFPA portion of TSA operable;
- Non-IFPA portion of TSA inoperable; and
- CRLU.

1.2 Scope and Objectives

The objective of this analysis was to provide statistical adjustment factors for the Vegetation Resources Inventory in support of the Timber Supply Analysis in the Fraser TSA.

2. METHODS

2.1 Overview of statistical adjustment

Statistical adjustment is the process of adjusting the values of the photo-interpreted variables in the inventory using information from the ground sampling observations. The statistical adjustment factors for Fraser TSA were developed using the current MSRM approach known as the "Fraser Protocol".

In the Fraser Protocol, ground observations are compared with photo-estimated values⁹ for each sampled polygon. A statistical model, typically ratio of means¹⁰, is then used to develop the adjustment factors. These factors are applied to all polygons in the photo-interpreted inventory database to produce the final adjusted inventory database. Under the current MSRM standard, only three inventory attributes are adjusted: age, height and volume. The Fraser Protocol is a sequential approach where adjustment factors for inventory age and height are computed first, a new "attribute-adjusted" inventory volume (based on the adjusted age and height) is calculated next, and finally, a volume adjustment factor is computed based on the "attribute-adjusted" inventory volume. This process is shown diagrammatically in Figure 1 below.

⁹ In VRI terminology, the ground sample values are referred to as PHASE II values and the photo-interpreted inventory values are referred to as PHASE I values.

¹⁰ Ratio-of-means is generally appropriate if the relationship between Y (ground attribute, in this case) and X (inventory attribute) is linear and passes through the origin. If these conditions are not met alternative adjustment approaches (such as linear regression, geometric mean regression, non-linear regression) may be explored. However, these alternatives also have their limitations and may produce undesirable characteristics in the adjusted population.

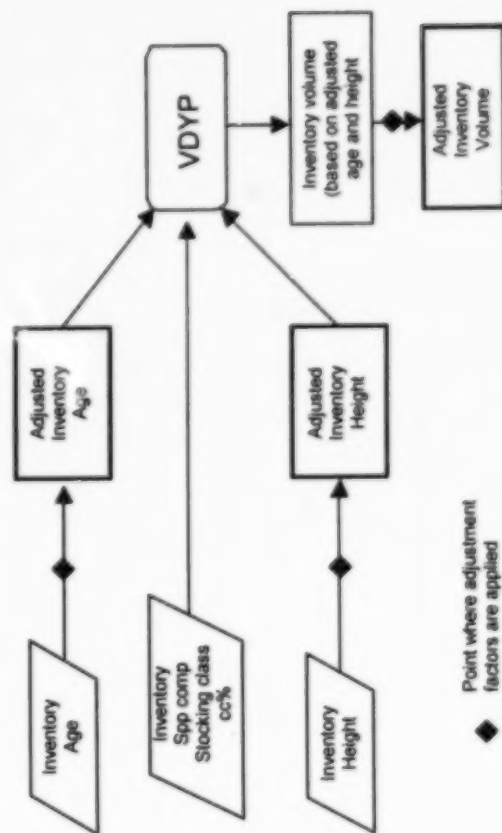


Figure 1: Overview of the Fraser Protocol for statistical adjustment of inventories.

2.2 Population for adjustment

Data was collected from the vegetated treed (VT) population. However, high variability was observed in the inventory and ground data below 30 years of age. In addition, inventory data in this age range is often used in a different manner in the timber supply analysis. For example, for polygons less than 30 years of age, estimated site index is often used in place of age and height for determining site growth potential. Hence after discussions with district and timber supply staff, it was decided to limit the adjustment to vegetated, treed polygons greater than 29 years of age¹¹.

¹¹ Refer to minutes of meeting. Initial adjustment factors were produced for the 0+ years VT population. However, there was concern about the impact of the variability of the young samples on the overall adjustment factor.

The samples below 30 years of age are currently being examined to determine if a more limited adjustment (perhaps age and site index) might be appropriate in this stratum¹².

2.3 Data sources

2.3.1 Phase I photo-interpreted inventory data

The Phase I data was processed through VEGCAP. Data was validated in October of 2001 and was made available for analysis on October 31, 2001¹³.

The data used to develop the adjustment factors was unprojected. That is the input age and height values (with a reference year of 1996 for all samples) was used. The alternative was to use the height and age values projected to 2001 that were also available. The use of the input age and height values was approved by analysis team at November 13, 2001 meeting. Hence all of the adjustments were based on the "age_in" and "height_in" values on the file.

All of the inventory data used in the adjustment was based on the rank 1 layer¹⁴. Operability came from original inventory data files¹⁵ except for the CRLU where operability was later provided in the file *dck_op.dbf*.

Inventory volumes used to develop the adjustment factors were generated in VDYP v.6.6d. Note that for the FIZ and PSYU's found in the Fraser TSA, VDYP will only produce volumes at the 17.5cm+ dbh utilization. That is, VDYP volumes at the 12.5cm+ dbh utilization could not be generated.

2.3.2 Phase II ground sample data

The Phase II ground data was recompiled with most current version of compiler¹⁶. The NVAF factors that were applied were based on the completed NVAF sampling in this unit. The compilation files¹⁷ used in this analysis were received on November 15, 2001. In total, 68 samples

¹² Part of the difficulty with adjusting the population <30 years was how the inventory height is projected in these stands. For stands less than 30 years, input height is not used to project height. Rather, height is projected based on age and site index (Tim Salkeld, pers. com.).

¹³ Files were processed by Tim Salkeld and provided by Gary Johansen. Filenames: *fra_an01.dbf*, *sample69.dbf*, *ch_psyu.dbf*, *dck_op.dbf*.

¹⁴ In processing the data, blank values for rank were encountered. Subsequent investigation by Gary Johansen and Tim Salkeld determined that the "blank" rank layers corresponded to the rank 1 layer.

¹⁵ The original inventory files were provided in the spring of 2001. This data was subsequently validated and reprocessed but for the current analysis, operability information (except for the CRLU) came from these original files. These files are listed by project below. Project 302 (IFPA): "IFPA_S50.dbf" for initial 50 samples (3 passes); "IFPA_SES.dbf" for first set of extra samples; "IFPA_SE2R.xls" for second set of extra samples; "5SAMPS1.xls" for "missed area" samples. Project 301 (non-IFPA portion of TSA): "TSA_S87.dbf" for initial 87 samples (5 passes); "TSA_SE.dbf" for first set of extra samples; "TSA_SE2.dbf" for second set of extra samples; "TSA_SE3.dbf" for third set of extra samples; "10samps1.xls" for "missed area" samples.

¹⁶ This compilation includes the so-called "regression fix" for VBAR.

from project 302 (IFPA), 89 samples from project 301 (non-IFPA portion of the TSA), and 35 samples from project DCK1 (CRLU) were compiled.

2.4 Data issues related to the analysis

Twelve samples for which compiled data were available were excluded from the analysis because they did not meet the "vegetated and treed" criterion for the population of interest. Among these were three samples from project 301 that were established in recently logged polygons (samples 23, 110 and 601). In addition, five samples from project DCK1 (8, 18, 21, 30 and 39) and four samples from project 301 (45, 60, 74 and 85) were classed as "vegetated, non-treed" and were hence excluded from the analysis.

In total, 180 "vegetated, treed" (VT) samples were available for analysis. Of these, 28 samples showed inventory ages less than 30 hence were not included in the development of the height, age and volume adjustment factors (see a discussion of the population for adjustment in section 2.2).

2.5 Data matching

For each VRI sample polygon, the ground sample data was matched with the corresponding inventory data for the same polygon. The ground and inventory data used in the development of the adjustment factors for the Fraser TSA are provided in Appendix A.

The ground heights and ages used in the adjustment were based on the average values for the T, S & L¹⁸ trees for the leading species (by basal area at 4cm + dbh utilization) on the ground. In the Vegetation Inventory File (VIF) format, inventory data (i.e. height and age) is available for the leading and second species. The objective in the matching process was to choose an inventory height and age (i.e. for either the leading or second species) so that the ground and inventory species "matched". If a match could not be made at the sp0¹⁹ level, conifer-to-conifer matches were allowed. However, conifer-deciduous matches were not considered acceptable. Details of the species matching process, included a description of 7 possible "cases" for matching, are provided in the VRI Draft Attribute Adjustment Procedures document available from the MSRM.

A total of 96 of the 180 VT samples available were matched at the leading species or sp0 level²⁰. A further 49 samples could be matched using the second species²¹. Twenty-four samples were based on conifer-to-conifer matches²². Three samples were matched based on conifer-to-conifer

¹⁷ Ground sample compilation files: FRASER_NC.xls; FRASER_NCS.xls; prj_302_nc.xls; prj_302_ncs.xls.

¹⁸ T or "top height" tree is the largest DBH in 0.01 ha plot, regardless of species; L or "leading species" tree is the largest DBH in 0.01 ha plot, of leading species; S or "second species" is the largest DBH in 0.01 ha plot, of second species. T and S trees are selected and measured at the IPC only whereas L trees are selected at the IPC and all auxiliary plots. For details, refer to Section 4.8 in the MSRM document "VRI Ground Sampling Procedures", January 2001 version 4.2.

¹⁹ sp0 refers to the 16 major species codes and is roughly equivalent to the genus level.

²⁰ 84 samples were matched based on "Case 1" and a further 12 samples matched based on "Case 3".

²¹ 38 samples were matched based on "Case 2" and a further 11 samples matched based on "Case 4".

²² These 24 samples represent "Case 5".

using the second species. Seven samples had no leading species at 4cm+ dbh on the ground and hence could not be matched and one sample was conifer-deciduous and hence was considered an unacceptable match.

2.6 Pre-stratification and sub-stratification

Polygons were selected for sampling using MPOS (multiple pass ordered systematic) methodology. Prior to sample selection, the population was pre-stratified into 5 strata:

- Polygons in the operable portion of the IFPA
- Polygons in the inoperable portion of the IFPA
- Polygons in the operable portion of the TSA (non-IFPA, non-CRLU only)
- Polygons in the inoperable portion of the TSA (non-IFPA, non-CRLU only)
- Polygons in the CRLU.

The analysis and the development of the adjustment factors maintained the sampling pre-stratification. In addition, further sub-stratification based on species groupings and age groupings was investigated in the operable portions of the IFPA and the TSA (non-I, r^2A)²³. Examination of the adjustment ratios and scatter plots of the data revealed that trends in the ground to inventory relationships appeared to differed by inventory leading species group. These trends appeared stronger than the age-related trends, particularly when the adjustment was limited to samples >29 years of age. Sub-stratification of age withing species group could not be supported by the available samples sizes.

Hence the final set of adjustment factors were produced for the following 11 strata:

- CRLU
- IFPA inoperable
- "TSA" inoperable (where "TSA" is the non-IFPA, non-CRLU portion of the TSA)
- IFPA operable; balsam, spruce or pine leading
- IFPA operable; fir leading
- IFPA operable; hemlock or cedar leading
- IFPA operable; other species leading
- "TSA" operable; balsam, spruce or pine leading

²³ Sample sizes in the CRLU and the inoperable areas could not support further sub-stratification.

- "TSA" operable; fir leading
- "TSA" operable; hemlock or cedar leading
- "TSA" operable; other species leading.

Because of the high variability observed in the "other species" sub-stratum, ratios in this stratum were based on the overall average of all species (i.e. all samples included, combined by the missed and non-missed areas within each species group based on relative area).

2.7 MPOS formulae used to compute adjustment ratios and sampling error

The formulae applied in this analysis were provided by Peter Ott²⁴. Please contact the biometrician at TIB for more information.

3. RESULTS AND DISCUSSION

3.1 Age and height adjustment

Age and height adjustment factors were computed for each of the 11 strata described in section 2.6. More detailed results, showing means and areas for missed area and non-missed area samples within each substratum can be found in Appendix XX. The adjustment ratios for height and age are summarized in Table 1. *Note that these factors apply only to vegetated, treed (VT) polygons > 29 years of age.*

²⁴ Biometrician, Research Branch, Ministry of Forests.

Table 1: Adjustment factors for height and age, by stratum for VT polygons >29 years.

Stratum	Height adjustment factor	Age adjustment factor
CRLU	0.960	0.881
"TSA" inoperable	0.849	0.697
IFPA inoperable	0.880	0.779
"TSA" operable		
BSP	0.900	0.847
F	1.034	0.847
HC	0.881	0.977
Other	0.899	0.877
IFPA operable		
BSP	0.948	0.969
F	0.993	0.980
HC	1.011	0.887
Other	0.986	0.941

3.2 Volume adjustment

Volume adjustment factors were produced based on loss factor (LF) and net volume adjusted (NVAF) compiled volumes. All compiled volumes used in the adjustment reflected a "mixed" utilization requested by timber supply branch. This "mixed" utilization was 17.5 cm+ net dwb for samples greater than 140 years on the inventory and 12.5cm+ net dwb for samples that were less than or equal to 140 years on the inventory.

The volume adjustment is based on the Fraser Protocol, hence the volume adjustment ratios provided in Table 2 below are intended to be applied to VDYP volumes produced after height and age have been adjusted using the factors in Table 1. The factors in Table 2 are to be applied against VDYP volumes produced for the 17.5cm+ dbh net dwb utilization. The resulting adjusted volume will reflect the utilization used in the compilation (i.e. the "mixed" utilization described in the preceding paragraph).

Table 2: Volume adjustment factors by stratum (to be applied after heights and ages have been adjusted based on Table 1). These factors reflect a "mixed" utilization: 17.5 cm+ net dwb for samples greater than 140 years on the inventory and 12.5cm+ net dwb for samples less than or equal to 140 years on the inventory.

Stratum	NVAF Volume adjustment factor	Loss Factor Volume adjustment factor
CRLU	0.925	0.959
"TSA" inoperable	1.160	1.281
IFPA inoperable	0.771	0.766
"TSA" operable		
BSP	1.009	0.996
F	1.001	0.997
HC	0.990	0.980
Other	1.016	1.031
IFPA operable		
BSP	1.200	1.154
F	1.065	1.065
HC	0.918	0.832
Other	1.059	1.013

3.3 Overall volume impact

The overall volume impact was assessed by comparing the ground compiled volume with the unadjusted inventory volume. It represents the potential volume impact that the adjustment suggested here would have on the current inventory in the Fraser TSA.

Table 3: Volume impact by stratum for NVAF and loss factors (based on a "mixed" utilization: 17.5 cm+ net dwb for samples greater than 140 years on the inventory and 12.5cm+ net dwb for samples less than or equal to 140 years on the inventory).

Stratum	NVAF Volume Impact	Loss Factor Volume Impact
CRLU	0.847	0.878
"TSA" inoperable	0.907	1.001
IFPA inoperable	0.627	0.622
"TSA" operable		
BSP	0.881	0.870
F	1.051	1.047
HC	0.827	0.819
Other	0.930	0.944
IFPA operable		
BSP	1.102	1.060
F	1.054	1.054
HC	0.941	0.852
Other	1.036	0.991

Given the complexities of the sample design and the modifications to the original design that arose over the course of the sampling, the variances for the combined ratio estimates used as adjustment factors were difficult to compute. In addition, the appropriate degrees of freedom for computation of a confidence interval was difficult to ascertain²⁵. However, assuming a t-value of 2, the overall sampling error for a ratio adjustment of the operable component of the VT inventory greater than 29 years of age (i.e. operable component of the CRLU, IFPA and remaining TSA) was about 17%.

²⁵ Most references do not even attempt to suggest formulae for confidence interval estimation for such complex sample estimators as those computed here.

4. APPENDIX A: GROUND AND INVENTORY DATA

Please contact Terrestrial Information MSRM for a copy of this data.

5. APPENDIX B: DETAILED RESULTS

Table C-1: Age adjustment factors for operable portions of IFPA and "TSA"

Inventory leading spp	Substratum	Area (VT, operable, >29yrs)		TSA				Age Adjustment			
		"TSA" area (ha)	IFPA area (ha)	n	Mean ground age	Mean inventory age	Ratio	n	Mean ground age	Mean inventory age	Ratio
Balsam, pine, spruce	non-missed area	74179.196	16254.528	13	170.523	211.538	0.847	10	151.52	156.3	0.969
	missed area	12048.462	216.974	3	189.167	160					
Hemlock, cedar	non-missed area	93051.555	15583.368	15	188.253	192.667	0.977	11	170.9	192.727	0.887
	missed area	2708.172	342.235								
Fir	non-missed area	92222.309	18413.073	15	96.747	114.2	0.847	12	92.308	97.5	0.980
	missed area	7630.212	2477.656					1	200.5	180	
Other (decid)	non-missed area	46135.956	4695.731	3	50.867	81.667	see *				see *
	missed area	124.848	139.676					1	61	50	
All spp combined *		328100.71	58123.241	49			0.877	35			0.941

* area wt'd combined ratio estimate by species and missed/non-missed areas. This was used as the adjustment factor for the "Other" stratum.

Table C-2: Height adjustment factors for operable portions of IFPA and "TSA"

Inventory leading spp	Substratum	Area (VT, operable, >29yrs)		Height Adjustment							
				TSA				IFPA			
				n	Mean ground height	Mean inventory height	Ratio	n	Mean ground height	Mean inventory height	Ratio
Balsam, pine, spruce	non-missed area	74179.196	16254.528	13	24.423	27.154	0.900	10	22.57	23.82	0.948
	missed area	12048.462	216.974	2	22.95	25.5					
Hemlock, cedar	non-missed area	93051.555	15583.368	20	28	31.765	0.881	10	27.7	27.4	1.011
	missed area	2708.172	342.235								
Fir	non-missed area	92222.309	18413.073	15	27.187	25.267	1.034	12	24.442	23.25	0.993
	missed area	7630.212	2477.656	1	16.1	28		1	25.6	36	
Other (decid)	non-missed area	46135.956	4695.731	3	20	29.333	see *	1	27.5	20	see *
	missed area	124.848	139.676								
All spp combined *		328100.71	58123.241	54			0.899	34			0.986

* area wt'd combined ratio estimate by species and missed/non-missed areas. This was used as the adjustment factor for the "Other" stratum.

Table C-3: Age adjustment factors for CRLU (operable and inoperable) and inoperable portions of IFPA and "TSA"

"TSA" inoperable	Area (ha)	n	Mean ground age	Mean inv age	Ratio	n	Mean ground height	Mean inv height	Ratio
non-missed area	179289.49	5	125.28	186.0		6	21.967	26.333	
	12098.721	1	164.4	150	0.697	1	18.4	15	0.849
IFPA inoperable	42157.82	15	145.46	188		15	20.727	23.667	
	716.373	1	83.1	30	0.779	1	10.9	6	0.880
CRLU (all samples)		21	66.257	75.238	0.881	21	23.49	24.476	0.960

Table C-4: NVAF volume adjustment factors for operable portions of IFPA and "TSA".

Inventory leading spp	Substratum	Area (VT, operable, >29yrs)		TSA				IFPA			
		"TSA" area (ha)	IFPA area (ha)	n	Mean ground vol/ha	Mean attr-adj'd inv vol/ha	Ratio	n	Mean ground vol/ha	Mean attr-adj'd inv vol/ha	Ratio
Balsam, pine, spruce	non-missed area	74179.196	16254.528	14	354.634	347.279	1.009	10	419.25	349.34	1.200
	missed area	12048.462	216.974	3	195.125	219.5					
Hemlock, cedar	non-missed area	93051.555	15583.368	22	435.338	439.705	0.990	13	384.506	418.808	0.918
	missed area	2708.172	342.235								
Fir	non-missed area	92222.309	18413.073	16	378.841	349.812	1.001	12	338.016	277.658	1.065
	missed area	7630.212	2477.656	1	38.716	387.000		1	262.604	541.8	
Other (decid)	non-missed area	46135.956	4695.731	4	221.329	178.475	See *	1	9.758	0	See *
	missed area	124.848	139.676					1	253.181	50.5	
All spp combined *		328100.71	58123.241	60			1.016	38			1.059

* area wt'd combined ratio estimate by species and missed/non-missed areas. This was used as the adjustment factor for the "Other" stratum.

Table C-5: Loss factor volume adjustment factors for operable portions of IFPA and "TSA"

Inventory leading spp	Substratum	Area (VT, operable, >29yrs)		Volume Adjustment (LF)							
				TSA				IFPA			
				n	Mean ground vol/ha	Mean attr-adj'd inv vol/ha	Ratio	n	Mean ground vol/ha	Mean attr-adj'd inv vol/ha	Ratio
Balsam, pine, spruce	non-missed area	74179.196	16254.528	14	347.297	347.279	0.996	10	403.005	349.34	1.154
	missed area	12048.462	216.974	3	209.704	219.5					
Hemlock, cedar	non-missed area	93051.555	15583.368	22	431.099	439.705	0.980	13	348.346	418.808	0.832
	missed area	2708.172	342.235								
Fir	non-missed area	92222.309	18413.073	16	377.55	349.812	0.997	12	340.218	277.658	1.065
	missed area	7630.212	2477.656	1	39.133	387.000		1	245.925	541.8	
Other (decid)	non-missed area	46135.956	4695.731	4	277.087	178.475	See *	1	5.246	0	See *
	missed area	124.848	139.676					1	244.607	50.5	
All spp combined *		328100.71	58123.241	60			1.031	38			1.013

* area wt'd combined ratio estimate by species and missed/non-missed areas. This was used as the adjustment factor for the "Other" stratum.

Table C-6: Volume adjustment factors for CRLU (operable and inoperable) and inoperable portions of IFPA and "TSA"

"TSA" inoperable	Area (ha)	n	Mean ground NVAF vol	Mean attr-adj'd inv vol	NVAF Ratio	n	Mean ground LF vol	Mean attr-adj'd inv vol	Loss factor Ratio
non-missed area	179289.49	10	208.696	193.67	1.160	10	234.474	193.670	
	12098.721	1	330.753	81.2		1	305.001	81.2	
IFPA inoperable	42157.82	16	214.093	278.475	0.771	16	212.555	278.475	
	716.373	1	39.278	0		1	39.786	0	
CRLU (all samples)		26	272.767	294.981	0.925	26	282.827	294.981	

Table C-7: NVAF volume impact for operable portions of IFPA and "TSA"

Inventory leading spp	Substratum	Area (VT, operable, >29yrs)		Volume Impact (NVAF)					
		"TSA" area (ha)	IFPA area (ha)	TSA			IFPA		
		n	Mean ground vol/ha	Mean unadj'd inv vol/ha	Ratio	n	Mean ground vol/ha	Mean unadj'd inv vol/ha	Ratio
Balsam, pine, spruce	non-missed area	74179.196	16254.528			14	354.634	396.471	0.881
	missed area	12048.462	216.974	3	195.125	257.4	10	419.25	380.28
Hemlock, cedar	non-missed area	93051.555	15583.368			22	435.338	526.341	0.827
	missed area	2708.172	342.235				13	384.506	408.669
Fir	non-missed area	92222.309	18413.073			16	378.841	332.919	1.051
	missed area	7630.212	2477.656	1	38.716	371.400	12	338.016	281.425
Other (decid)	non-missed area	46135.956	4695.731			4	221.329	177.275	See *
	missed area	124.848	139.676				1	9.758	0
All spp combined *		328100.71	58123.241	60			1	253.181	66.9
							38		1.036

* area wt'd combined ratio estimate by species and missed/non-missed areas. This was used as the adjustment factor for the "Other" stratum.

Table C-8: LF volume impact for operable portions of IFPA and "TSA"

Inventory leading spp	Substratum	Area (VT, operable, >29yrs)		Volume Impact (LF)								
		"TSA" area (ha)	IFPA area (ha)	TSA				IFPA				
				n	Mean ground vol/ha	Mean unadj'd inv vol/ha	Ratio	n	Mean ground vol/ha	Mean unadj'd inv vol/ha	Ratio	
Balsam, pine, spruce	non-missed area	74179.196	16254.528	14	347.297	396.471	0.870		10	403.005	380.28	1.060
	missed area	12048.462	216.974	3	209.704	257.4						
Hemlock, cedar	non-missed area	93051.555	15583.368	22	431.099	526.341	0.819		13	348.345	408.669	0.852
	missed area	2708.172	342.235									
Fir	non-missed area	92222.309	18413.073	16	377.55	332.919	1.047		12	340.218	281.425	1.054
	missed area	7630.212	2477.856	1	39.133	371.400			1	245.925	541.8	
Other (decid)	non-missed area	46135.956	4695.731	4	277.087	177.275	See *		1	5.246	0	See *
	missed area	124.848	139.676						1	244.607	66.9	
All spp combined *		328100.71	58123.241	60			0.944		38			0.991

* area w/d combined ratio estimate by species and missed/non-missed areas. This was used as the adjustment factor for the "Other" stratum.

Table C-9: Volume impact for CRLU (operable and inoperable) and inoperable portions of IFPA and "TSA"

"TSA" inoperable	Area (ha)	n	Mean ground NVAF vol	Mean unadjusted inv vol	NVAF Impact	n	Mean ground LF vol	Mean unadjusted inv vol	Loss factor Impact
non-missed area	179289.49	10	208.696	245.090		10	234.474	245.09	
	12098.721	1	330.753	144.1	0.907	1	305.001	144.1	1.001
IFPA inoperable	42157.82	16	214.093	342.581		16	212.555	342.581	
	716.373	1	39.278	0	0.627	1	39.786	0	0.622
CRLU (all samples)		26	272.767	322.027	0.847	26	282.827	322.027	0.878

6. APPENDIX C: GRAPHICAL ADJUSTMENT RELATIONSHIPS

Figure D-1: Adjustment relationships for balsam/spruce/pine stratum for the TSA and IFPA, operable only, VT, age >29 years.

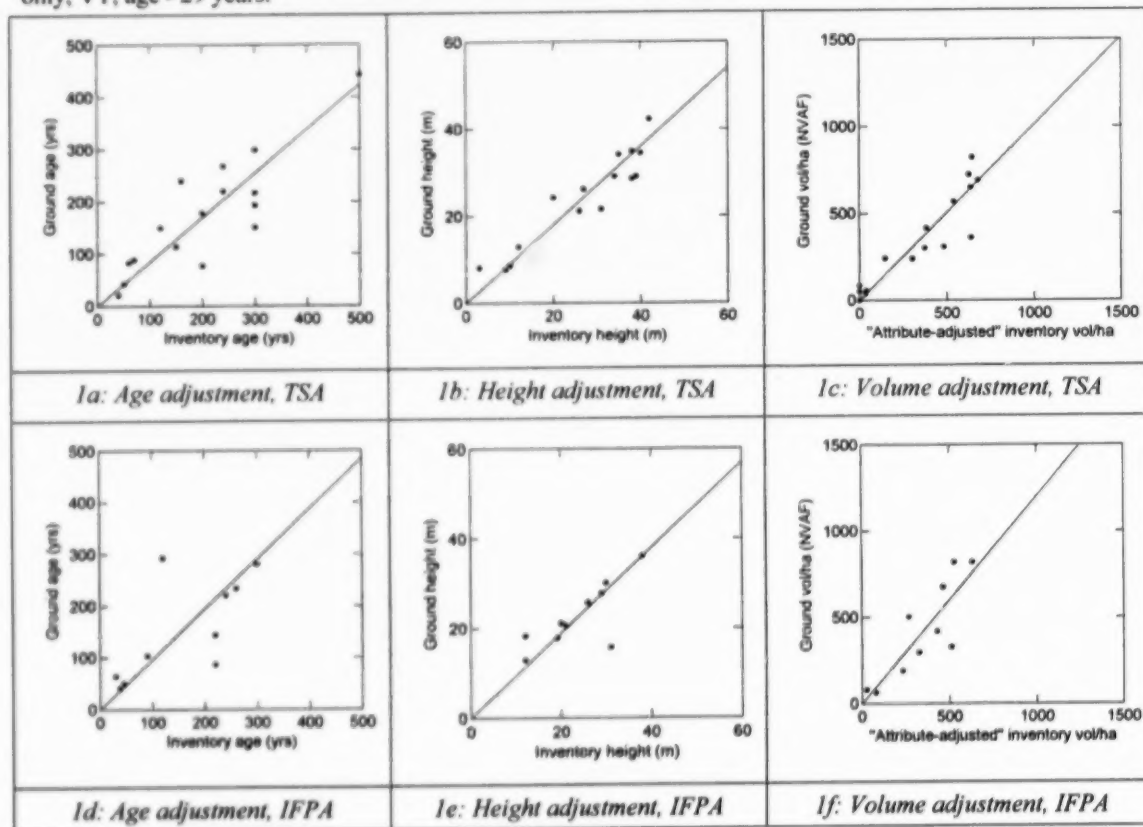


Figure D-2: Adjustment relationships for fir stratum for the TSA and IFPA, operable only, VT, age >29 years.

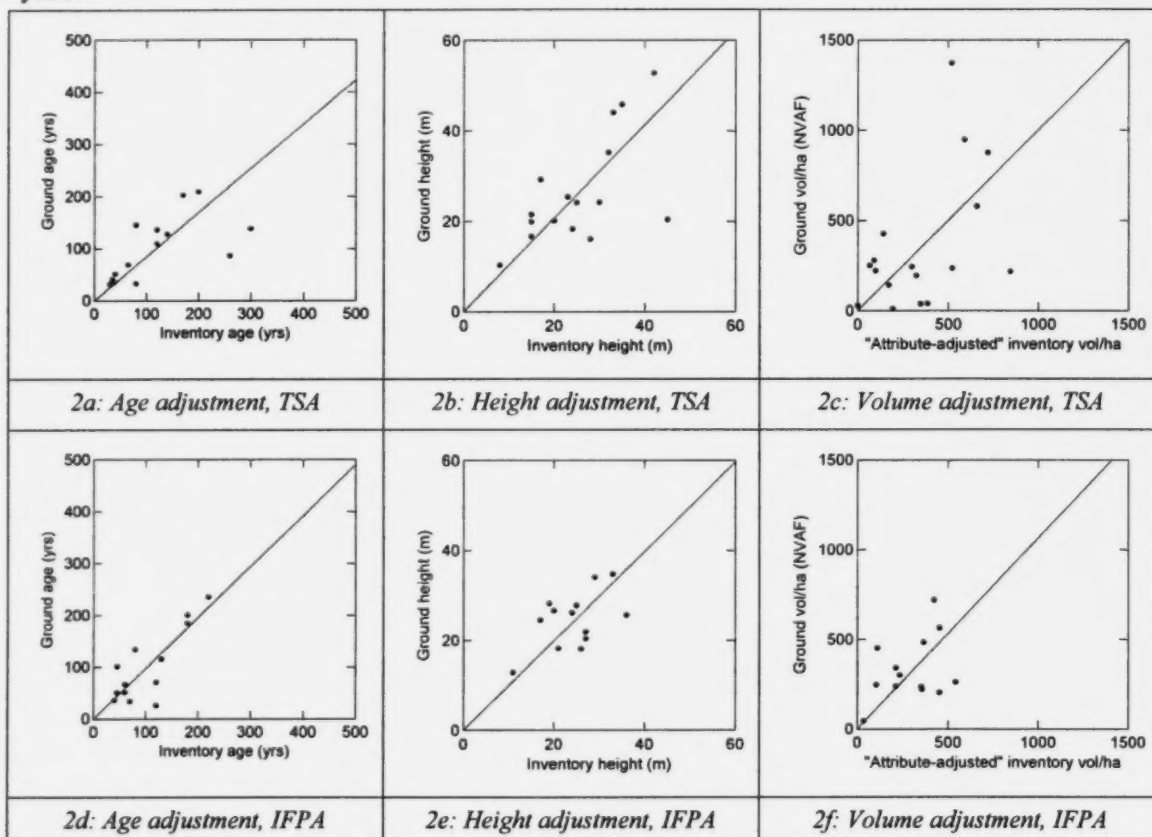


Figure D-3: Adjustment relationships for hemlock/cedar stratum for the TSA and IFPA, operable only, VT, age >29 years.

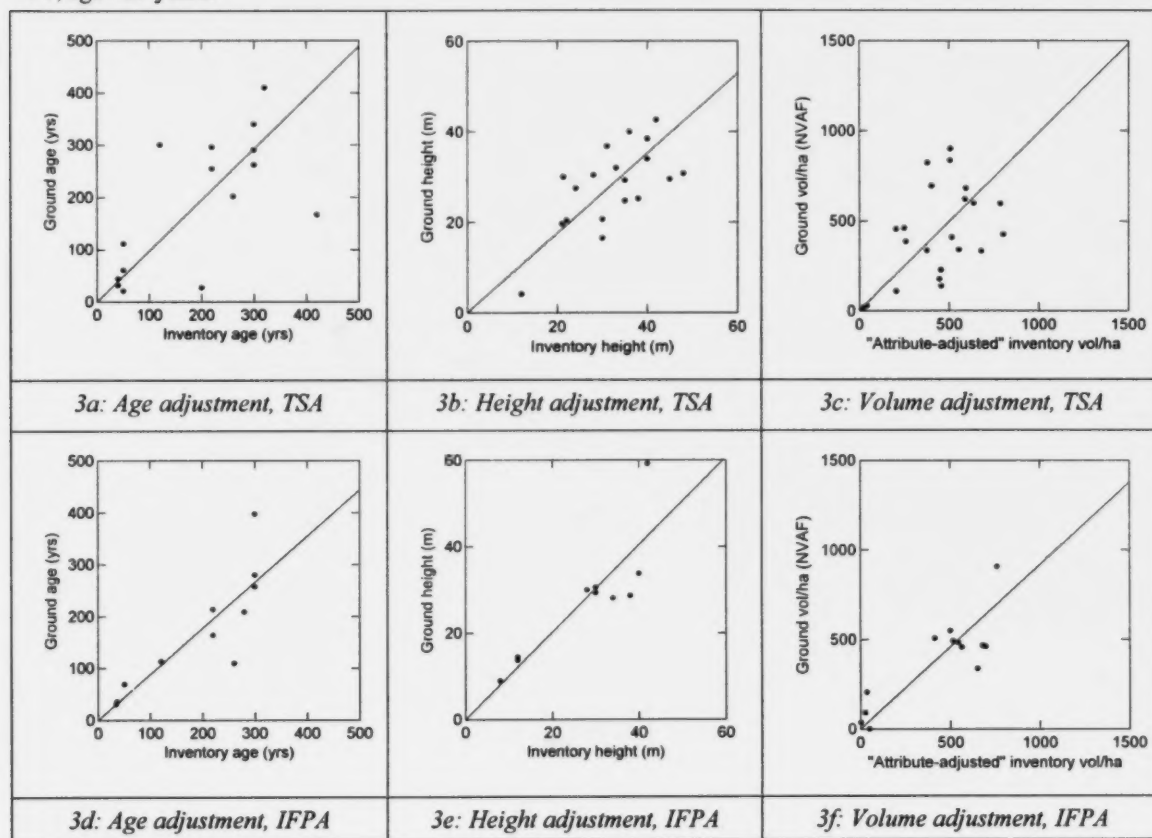
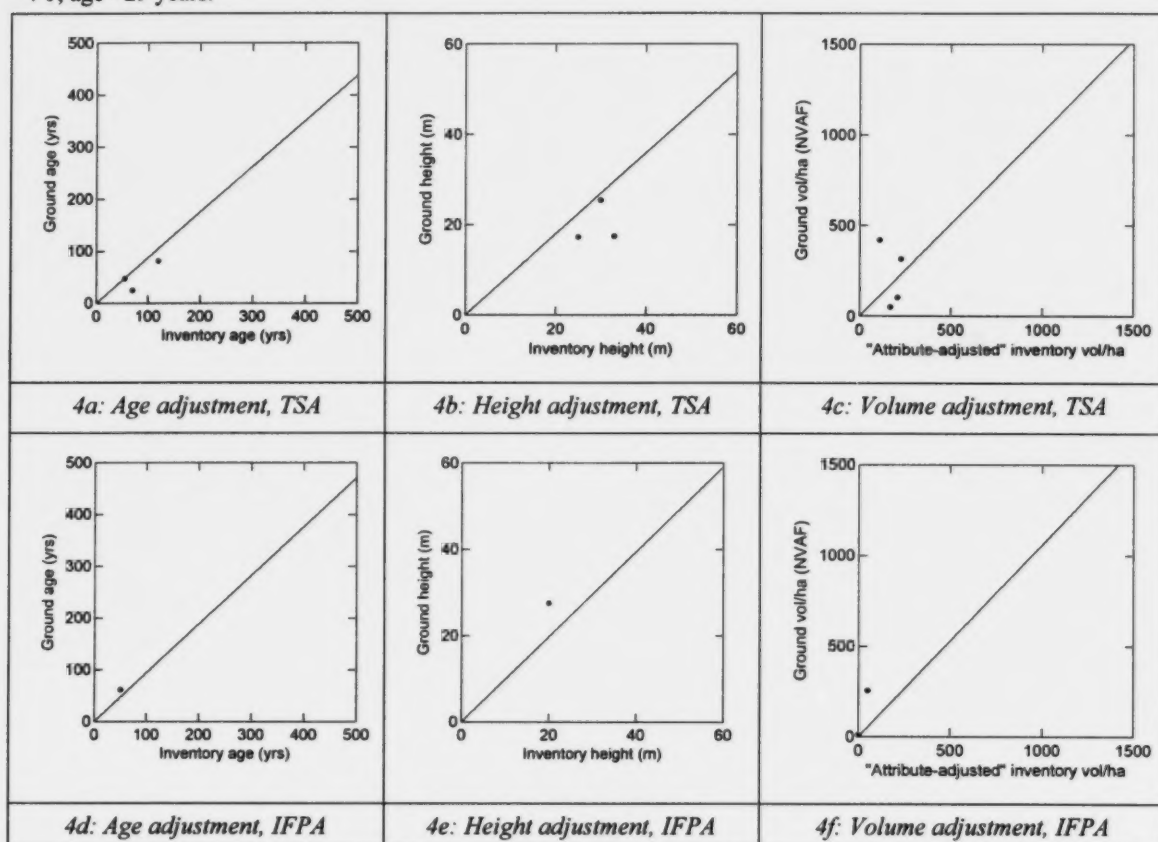


Figure D-4: Adjustment relationships²⁶ for "other" species stratum for the TSA and IFPA, operable only, VT, age >29 years.



²⁶ The lines on the graph represent the adjustment ratios that are to be applied to the "other spp" stratum. These adjustment ratios were developed using a combined ratio estimate based on samples from all of the 4 species strata (i.e. samples from all non-"other spp" strata plus samples from "other spp" stratum within each of the TSA-operable and the IFPA-operable). These graphs show how the ratios based on all of the samples fit the limited number of samples that were available in the "other spp".

Figure D-5: Adjustment relationships for the TSA and IFPA, inoperable, VT, age >29 years.

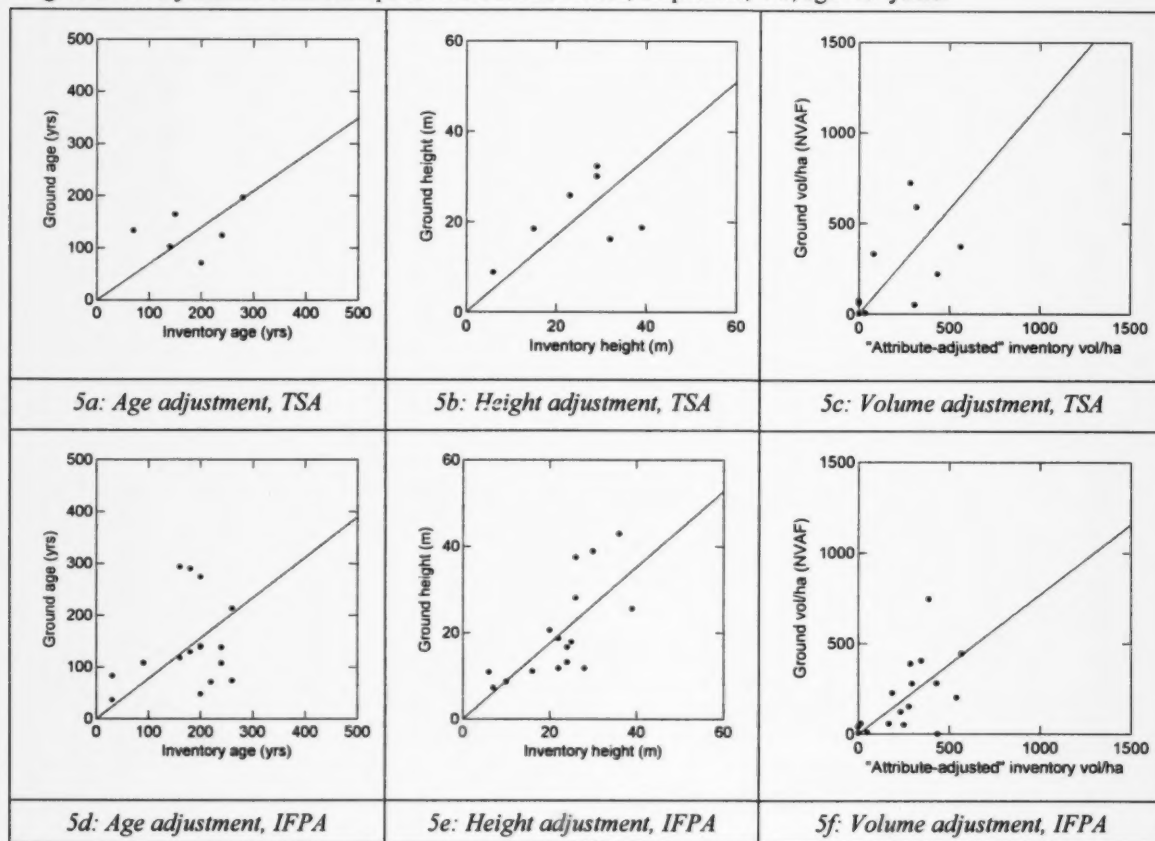
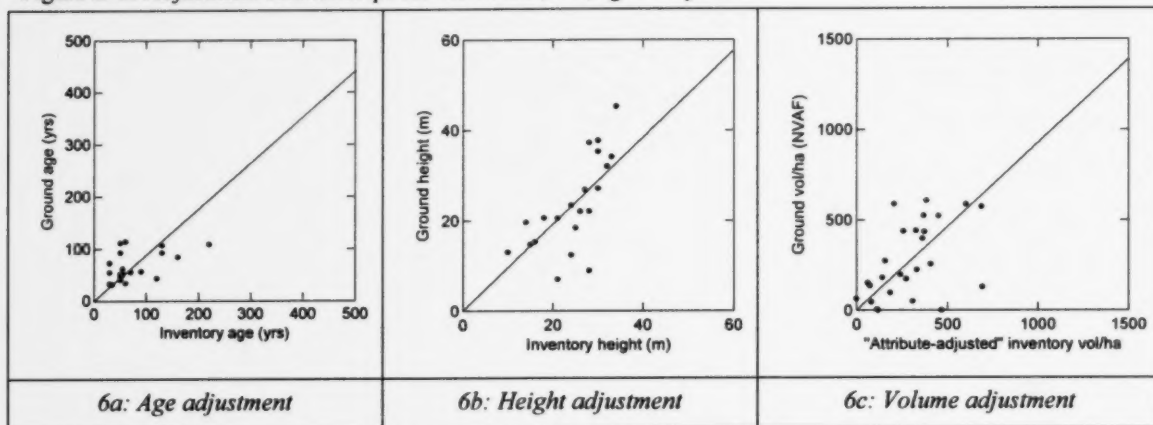


Figure D-6: Adjustment relationships for the CRLU, VT, age >29 years.



VRI Sampling Plan for the Fraser TSA and the Interfor Hope Logging IFPA

Submitted to John Markila
Vancouver Forest Region
Nanaimo, B.C.
Project: IFH-033-010

20 August 1999

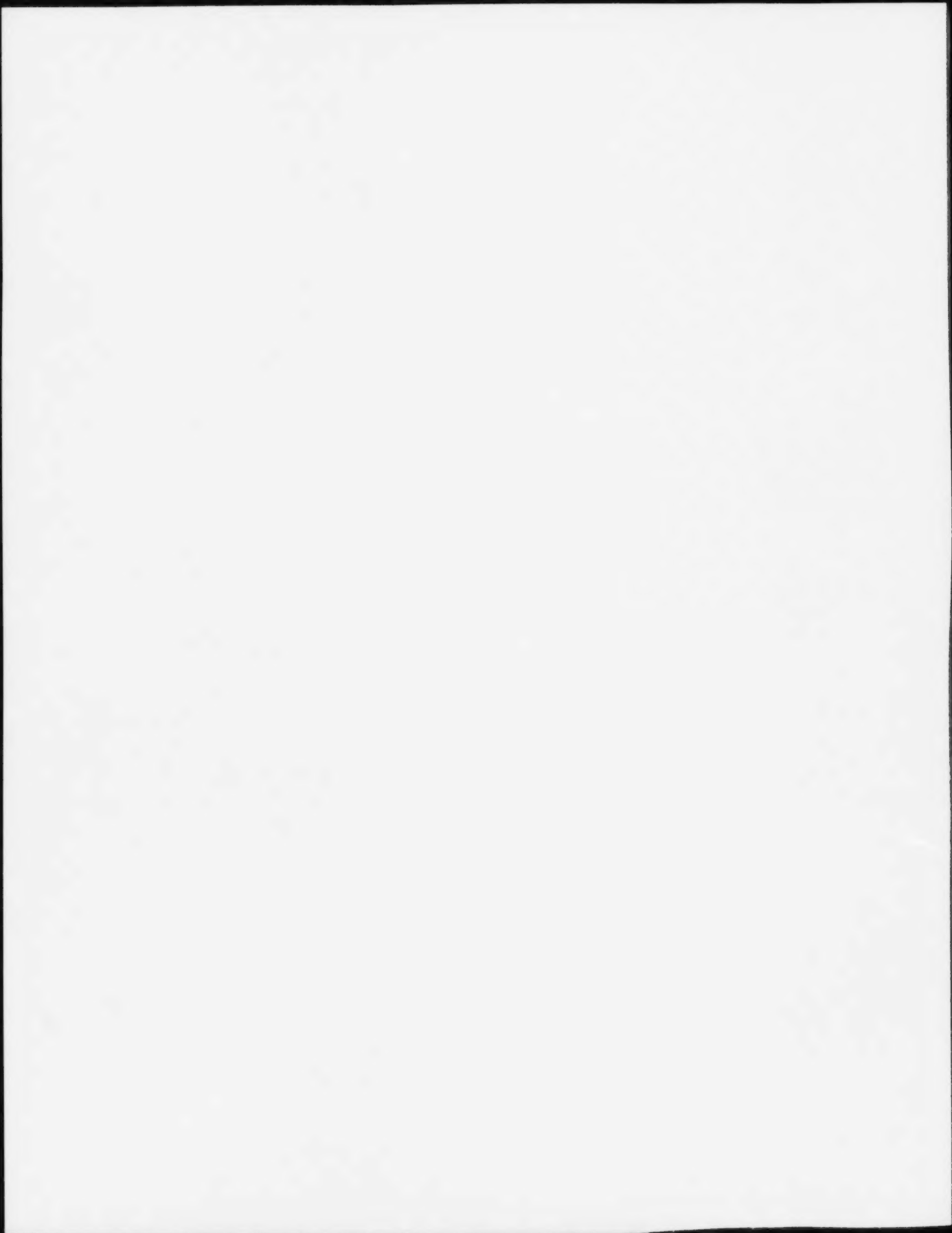


TABLE OF CONTENTS

1	INTRODUCTION	3
1.1	BACKGROUND	3
1.2	DOCUMENT OBJECTIVES	3
2	FRASER TSA LANDBASE	4
3	GROUND SAMPLING PLAN	5
3.1	OBJECTIVES	5
3.2	SAMPLING APPROACH	5
3.3	TARGET POPULATION	5
3.4	SAMPLE SIZE	5
3.5	MEASUREMENTS	6
3.6	SAMPLE SELECTION	6
3.7	NET VOLUME ADJUSTMENT FACTOR SAMPLING	6
3.8	WITHIN POLYGON VARIATION SAMPLING	6
3.9	COMPILATION	7
4	PROJECT IMPLEMENTATION PLAN	8
4.1	OVERVIEW	8
4.2	SCHEDULE – IFPA AREA	8
4.3	SCHEDULE – REMAINING AREA OF TSA	9
4.4	SAMPLE PACKAGES	11
4.5	PROJECT SUPPORT	11
4.6	FIELDWORK	11
4.7	QUALITY ASSURANCE	12
4.8	DATA COMPILATION, ANALYSIS, AND ADJUSTMENT	12
4.9	ROLES AND RESPONSIBILITIES	12
	APPENDIX A	14
	APPENDIX B	15
	APPENDIX C	17
	APPENDIX D	20
	APPENDIX E	22

List of Tables

Table 1. Chilliwack Forest District landbase.....	4
Table 2. Sample sizes for ground sampling in the Vegetated Treed area of the Fraser TSA.....	5
Table 3. Illustration of inventory compilation before adding samples to IPFA Area.	22
Table 4. Illustration of inventory compilation <i>after</i> adding samples to IPFA Area.	22

List of Figures

Figure 1. Project activities in the IFPA area of the Fraser TSA.....	9
Figure 2. Project activities in the IFPA area of the Fraser TSA.....	11
Figure 3. Comparison of population and sample percentages by landscape unit.	20
Figure 4. Comparison of population and sample percentages by landscape unit.	20
Figure 5. Comparison of population and sample percentages by landscape unit.	21
Figure 6. Comparison of population and sample percentages by landscape unit.	21

7. INTRODUCTION

7.1 Background

The inventory in the Fraser Timber Supply Area (TSA) is being upgraded. In 1996, the Ministry of Forests (MOF) Chilliwack Forest District and Vancouver Forest Region initiated a Vegetation Resources Inventory (VRI) Phase I (photo interpretation) project for the Fraser Timber Supply Area (TSA). This photo interpretation project has just been completed. As well, approximately 40 sample clusters have been installed in 1998 in the Chilliwack Landscape Unit (#417).

Interfor has been awarded an Innovative Forest Practices Agreement (IFPA) for the Manning, Yale, and Silverhope landscape units in the TSA.²⁷ Interfor plans to review and upgrade the existing inventory in the IFPA area over a two-year period.²⁸ This plan will include completion of Phase II ground sampling to check the accuracy of the new VRI Phase I in 1999, and to adjust the inventory in 2000. Interfor will also cooperate with the MOF to complete Phase II ground sampling in the remainder of the TSA (1999-2000). This document is a ground-sampling plan for the timber emphasis VRI in the Fraser TSA, including Interfor's IFPA area.

The ground sampling in the TSA will involve installing timber emphasis sample clusters and net volume adjustment factor (NVAF) sampling. This ground sampling, followed by statistical adjustment of the new Phase I estimates, will give higher confidence in the timber volume estimates in the TSA operable landbase. Specifically, the adjusted VRI will:

- Address the timber inventory accuracy concerns in the TSA- an inventory audit in 1995 and 1996 indicated that the inventory volume was over-stated on average by approximately 23%.
- Meet the timber inventory needs of Interfor's IFPA. Interfor requires accurate estimates of the standing crop inventory and annual growth, to model the effects of forest management at the stand and forest levels in the spatial timber supply analysis process.

7.2 Document Objectives

This report outlines the sampling plan for collecting inventory data to adjust the inventory in the Fraser TSA. A.Y. Omule, PhD, RPF of J.S. Thrower and Assoc. prepared this report under contract to Interfor. This report is submitted for approval by the MOF and Interfor. A preliminary plan was reviewed and verbally approved on July 29, 1999 by the MOF (Vancouver Forest Region, Chilliwack Forest District and Resources Inventory Branch) and Interfor.

²⁷ The objective of the IFPA is to increase the harvest level in the IFPA area while considering local social, environmental, and economic issues. The strategy to achieve the IFPA objective involves implementing various technical program components, including timber inventory review and upgrade. The purpose of the timber inventory review and upgrade is to ensure accurate estimates of the inventory and growth and yield.

²⁸ Interfor Hope Logging Innovative Forestry Practices Agreement. Draft Forestry Plan No.1 July 9, 1999.

8. FRASER TSA LANDBASE

The Fraser TSA is approximately 1,023,023 ha, of which approximately 751,912 ha are Vegetated Treed (VT) (PCL Landcover Classification Scheme, or BCLCS).²⁹ Approximately 520,974 ha (or 51%) of the TSA landbase is considered operable (Table 2). The TSA area excludes the majority of urban areas, woodlots, Greater Vancouver Watershed District, major provincial parks and recreational areas, UBC research Forest, and the TFLs (26 and 43).

Interfor's Hope Logging IFPA total area is approximately 194,319 ha, which is about 13% of the total TSA area. The IFPA includes the Yale, Silverhope, and Manning landscape units in the TSA. Within the IFPA, 112,518 ha are VT; however, only about 70,157 ha of the IFPA area is considered operable.

Table 2. Chilliwack Forest District landbase.

Landbase	IFPA	Non-IFPA	Total
TSA			
VT - Operable	70,157	450,817	520,974
VT - Inoperable	42,361	191,577	233,938
Non-VT	19,584	248,527	268,111
8.1.1 Subtotal - TSA	132,102	890,921	1,023,023
Other Areas*	62,218	328,557	*585,094
8.1.2 Total - District	194,319	1,219,478	1,413,797

* Majority of urban areas, woodlots, Greater Vancouver Watershed, provincial parks and recreational areas, TFLs and UBC Research Forest.

**Does not include the lower mainland mapsheets not photo interpreted.

This ground sampling plan focuses on the VT areas of the TSA (754,910 ha), with emphasis on the VT operable landbase (69%).

²⁹ These area statistics are based on the new Phase I data.

9. GROUND SAMPLING PLAN

9.1 Objectives

The objectives of the ground sampling are to:

1. Install adequate samples in the IFPA area to check the overall accuracy of the timber inventory (inventory audit) in the Vegetated Treed landbase.
2. Install adequate samples in the TSA to adjust the inventory in the VT landbase. Emphasis will be on the operable landbase (as defined in the database); the sampling will aim is to achieve a sampling error of $\pm 10\%$ (90% probability)³⁰ for net timber volume (gross volume less stumps, tops, decay, waste and breakage) in the operable landbase.

9.2 Sampling Approach

The overall approach is to select adequate sample clusters over the VT area in the IFPA to achieve Objective 1, and to install additional sample clusters in the remainder of the TSA area to achieve Objective 2. The IFPA Area and the Remaining Area (of the TSA) will be treated as two separate sub-populations for sampling and analysis purposes. The inventory results from the two sub-populations can then be combined to provide overall TSA totals (Section 3.8).

9.3 Target Population

The target population is the VT landbase in the IFPA area (Objective 1) (520,974 ha) and in the entire TSA (Objective 2) (754,910 ha) (Table 1). The VT classification is used to approximate the productive forestland. Within the VT area, for the IFPA area or the remainder of the TSA, about 80% of the sampling effort will be allocated to the operable landbase and 20% to the inoperable area.

9.4 Sample Size

A total of 137 sample clusters will be installed in the TSA, of which approximately 50 will be in the IFPA area (Table 3). The 110 TSA sample clusters in the operable landbase (40 sample clusters in the IFPA area and 70 in the Remainder of the TSA) aim to achieve the sampling error stated in Objective 2 (assuming a coefficient of variation of approximately 55%). This target sampling error is associated with a 90% probability.

Table 3. Sample sizes (number of sample clusters) for ground sampling in the Vegetated Treed area of the Fraser TSA.

Target Population	Operable	Inoperable	Total Sample
IFPA Area	40	10	50
Remainder of TSA	70	17	87
<i>Grand Total</i>	<i>110</i>	<i>27</i>	<i>137</i>

³⁰ The 90% probability, which is lower than the MOF standard of 95% probability, was chosen as a balance between cost and desired precision. The MOF standard is currently under review.

meaning that there is a 10% chance the true overall net volume in the TSA may be outside the confidence limits estimated with the target sampling error. The MOF Region and District staff and Interfor have indicated, after considering other factors such as inventory costs, that this level of uncertainty was reasonable for timber supply analysis.³¹

The TSA sample clusters that fall in Landscape Unit 417 (Chilliwack) do not have to be installed as 40 sample clusters have already been installed in this Unit. The data from these 40 sample clusters will be appropriately weighted (by the number of hectares each sample cluster represents) and combined with the data from the new TSA sample clusters.

The number sample clusters in the IFPA area was based on available budget for the 1999 field season. The suggested sample size (50) could result in a sampling error of net volume of approximately 13% (90% probability, assuming a CV of 55%).

9.5 Measurements

The ground samples will be VRI *Timber Emphasis (TE)* sample clusters. Measurements will be based on the VRI Ground Sampling manual Version 4. These TE sample clusters will also provide a sampling framework for additional sampling, such as District full-VRI, that may be required in the future.

9.6 Sample Selection

The sample polygons for the IFPA area and for the Remainder of TSA samples will be selected separately by the MOF Resources Inventory Branch from two sorted lists compiled from the new Phase I file. Each list will include all the VT and will be sorted by land type (BCLCS), leading tree species, age, and site index (Appendices A, B, C, and D).

9.7 Net volume adjustment factor sampling

Net Volume Adjustment Factor (NVAF) sampling is one of the VRI support activities. It involves destructive sampling of sample trees to determine actual net volume, which is compared to the net volume estimated from the VRI call grading and net factoring process. The NVAF sampling, which is used to account for hidden decay and possible taper equation bias, will be conducted to check and adjust the net volume in the TSA. A total of 15 trees selected from approximately 5 locations will be destructively sampled for NVAF in the IFPA area in 1999. Approximately the same number will be selected in the Remaining Area of the TSA in 2000.

9.8 Within Polygon variation sampling

Within Polygon Variation (WPV) sampling is also a supporting activity of the VRI. It provides information for expressing the total inventory error and the accuracy of individual polygon estimates. The WPV sampling may be completed in 2000 in the entire TSA.

³¹ Reducing the level of uncertainty to 5% would have increased the sample size in the TSA by approximately 40%.

Sampling for WPV involves detailed sampling of individual sample polygons (10). The sample polygons should be selected at random if the selection is made from the polygons picked for the VRI ground sampling. Alternatively, the sample polygons can be selected independent of the VRI ground sampling, in which case they should be selected with probability proportional to area. Well-distributed clusters of 20 plots are established within each sampled polygon to estimate tree attributes.

Results from these detailed measurements will be assumed as the *true* values for the sampled polygons, and will be compared to the adjusted polygon values.

9.9 Compilation

The inventory in the TSA should be compiled such that adding samples to the Hope IFPA area within the TSA and compiling the IFPA area separately does not affect the estimates of volume in the remainder of the TSA. One way to compile the inventory is:

1. *Consider the TSA operable landbase as having two sub-populations (strata): the IFPA Area and the Remaining Area.*
2. *Calculate the average volume in each stratum using the samples in the stratum.*
3. *Calculate the weight of each stratum as the relative areas of the strata.*
4. *Calculate the overall TSA average volume as an area-weighted average of the strata means in 2. above.*

The addition of samples in the IFPA area will affect only the average volume in the IFPA area, but not the average volume in the Remaining Area. Furthermore, the change in the average volume in the IFPA area (before and after additional samples) will likely be small, thus the overall TSA volume change will also be small. A simple example of these calculations is given in Appendix E.

10. PROJECT IMPLEMENTATION PLAN

10.1 Overview

Completion of ground sampling in the TSA and IFPA area is planned for the 1999-2000 field seasons. Funding sources for the ground sampling include the IFPA, MOF, and Forest Renewal BC. In 1999, the 50 sample clusters falling in the IFPA area and the approximately 45 sample clusters in the remainder of the TSA will be installed. The remainder of the sample clusters will be installed in 2000.

Thrower & Associates will manage this project (the IFPA and Remaining Area) on behalf of Interfor. A separate schedule is developed for sampling the IFPA area and the remainder of the TSA.

10.2 Schedule – Ifpa Area

The VRI in the IFPA area will be implemented in 1999 as follows (Figure 2):

1. Select the sample polygons (July 9-August 10) (Resources Inventory Branch).
2. Prepare and submit a Sampling Plan (this Plan) for approval by the MOF (June 11 - July 30) (J.S. Thrower & Associates for Interfor).
3. Select sample locations in polygons using GIS (August 10-13) (Vancouver Forest Region).
4. Prepare sample packages; each to include photo stereo-pair for access, document photo photocopies, sample cluster location map (1:10,000), and access maps (1:20,000) (August 10-13) (Vancouver Forest Region).
5. Tender and select contract crews and an independent Check-cruiser (August 16-23) (J.S. Thrower & Assoc.).
6. Award contracts to field crews (August 24) (Interfor).
7. Prepare a fieldwork plan that includes two batches of 32 and 18 sample clusters to ensure an unbiased sample at the end of the field season. Select at random a sub-sample of 5 sample polygons for NVAF sampling from the 50 sample clusters; identify these NVAF sample polygons and ensure they are sampled early in the field season, to enable sample tree selection (August 16-24) (J.S. Thrower & Assoc.).
8. Locate and measure VRI sample clusters in the first batch; enter and edit the data (September 1-30) (Field contract crew). The Vancouver Forest region will spot-check the data (compare field card data to the entered data).
9. Locate and measure VRI sample clusters in the remaining batch; enter and edit data (October 1-30) (Field contract crew).
10. Conduct quality assurance (10% check) (September 2-30 and October 2-30) (Independent Check-cruiser).
11. Sample NVAF sample clusters (September 1-13) (Independent Check-cruiser)

12. Complete stem analysis (September 15 to October 30) (Contract crew).³²
13. Validate and compile data from completed sample clusters and prepare inventory summary reports (October 30- November 30) (MOF).³³
14. Conduct statistical analysis and adjust inventory files (if necessary) prior to timber supply analysis (December 1-30) (J.S. Thrower & Assoc.).

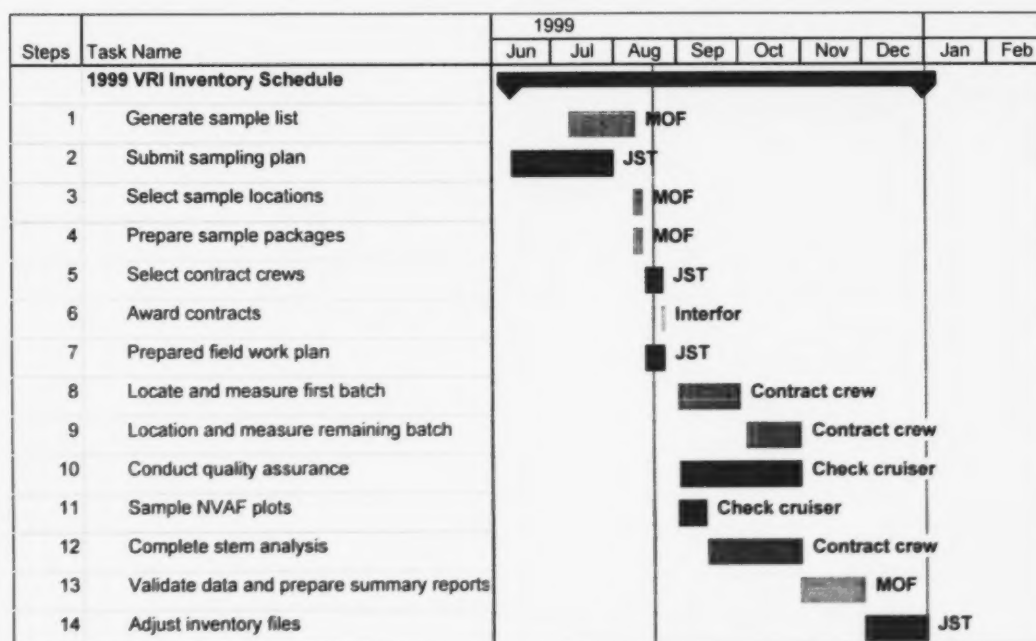


Figure 2. Project activities in the IFPA area of the Fraser TSA.

10.3 Schedule – Remaining Area of TSA

The VRI in the Remaining area of the TSA outside the IFPA area will be implemented over two field seasons: approximately 45 sample clusters in 1999 and the remainder (approximately 42) in 2000. The NVAF will be done in 2000. The project will be implemented as follows (Figure 2):

1999 Field Season

1. Select the sample polygons (July 9-August 10) (Resources Inventory Branch).

³² J.S. Thrower & Assoc. will prepare the tree-sampling matrix, and select the sample trees.

³³ J.S. Thrower & Assoc. will ensure data submitted to MOF is clean.

2. Prepare and submit a Sampling Plan (this Plan) for approval by the MOF (June 11 - July 30) (J.S. Thrower & Associates for Interfor).
3. Select sample locations in polygons using GIS (August 10-13) (Vancouver Forest Region).
4. Prepare sample packages; each to include photo stereo-pair for access, document photo photocopies, sample cluster location map (1:10,000), and access maps (1:20,000) (August 10-13) (Vancouver Forest Region).
5. Prepare a fieldwork plan that includes two batches of 30 and 15 sample clusters each, to ensure an unbiased sample at the end of the field season. Select at random a sub-sample of 5 sample polygons for NVAF sampling from the 87 sample clusters; identify these NVAF sample polygons and ensure they are sampled in 1999 or early in the 2000 field season, to enable sample tree selection (August 16-31) (J.S. Thrower & Assoc.).
6. Locate and measure VRI sample clusters in the first batch; enter and edit the data (September 1-October 8) (Field contract crew). The Vancouver Forest region will spot-check the data (compare field card data to the entered data).
7. Locate and measure VRI sample clusters in the second batch; enter edit data (October 11-30) (Field contract crew).
8. Conduct quality assurance (10% check) (September 2-8 and October 11-30) (Independent Check-cruiser).

2000 Field Season

9. Prepare for the second field season. This will include calculation of the CV based on the standard error of the regression for net volume. The remaining number of samples required to achieve the stated desired precision can then be accurately determined using standard procedures. (Week 1) (MOF)
10. Sample NVAF sample clusters (Week 2-3) (Independent Check-cruiser)
11. Complete stem analysis (Week 4-8) (Contract crew).³⁴
12. Locate and measure remaining VRI sample clusters (calculated in Step 11) (Week 2-6) (Contract Crew).
13. Conduct WPV sampling (Week 7-8) (Contractor).
14. Validate and compile data from completed sample clusters and prepare inventory summary reports (Week 9) (MOF).³⁵
15. Adjust inventory files prior to timber supply analysis (Week 10) (MOF).

³⁴ J.S. Thrower & Assoc. will prepare the tree-sampling matrix, and select the sample trees.

³⁵ J.S. Thrower & Assoc. will ensure data submitted to MOF is clean.

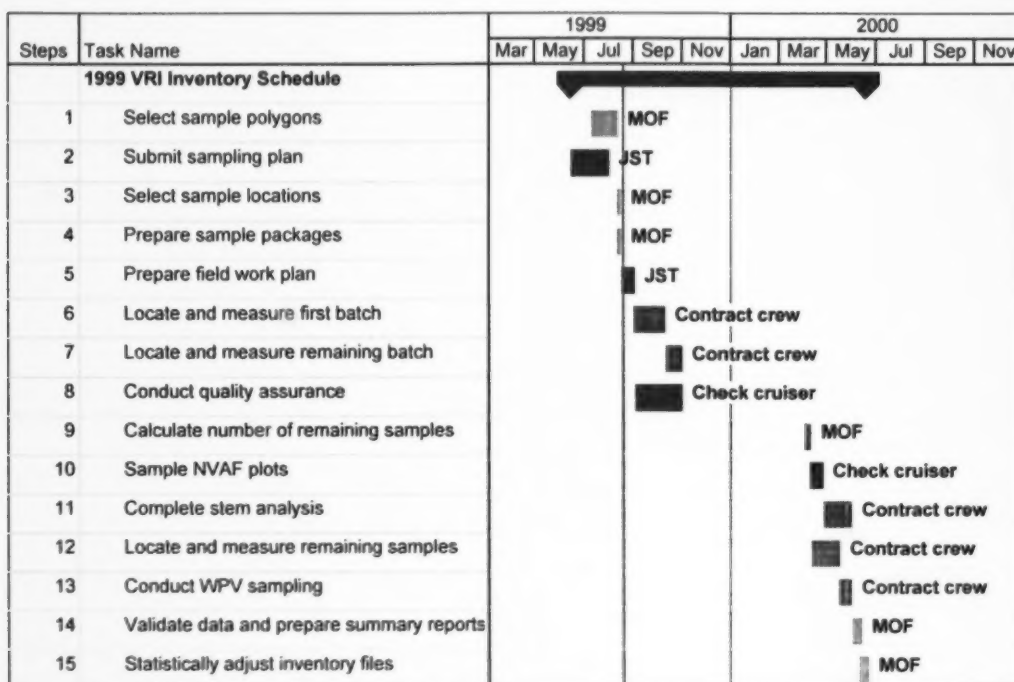


Figure 3. Project activities in the IFPA area of the Fraser TSA.

10.4 Sample Packages

Field sample packages must be prepared and approved by the MOF prior to beginning fieldwork. They should include most current photo stereo-pairs for access, copy of document photo (where possible), sample cluster location maps (1:10,000), and access maps (1:20,000) clearly indicating sample cluster location and polygon boundaries; and overview maps (1:250,000) for general polygon location. Maps will be plotted showing the VRI grid overlays and selected sample locations. Sample locations within a polygon will be selected using GIS.

10.5 Project Support

Provision of field supplies such as aluminum stakes, field maps, photos, field cards, and equipment (including GPS) will be the responsibility of the contract crews. Helicopter use will be provided and arranged by J.S. Thrower & Associates.

10.6 Fieldwork

Fieldwork will be completed using VRI measurement protocols and certified crews. The VRI Card Types 1-3 and 8-11 will be completed according the VRI Ground Sampling version 4. J.S. Thrower & Associates will manage the fieldwork contracts and ensure data quality.

10.7 Quality Assurance

Quality assurance must be conducted. The VRI quality assurance standards require inspection of at least 10% of the samples. The field crews are responsible for the quality control of their own work.

10.8 Data Compilation, Analysis, and Adjustment

The MOF Resources Inventory Branch will complete data compilation; contract field crews will do data entry. J.S. Thrower & Assoc. will complete the statistical analysis and database adjustment of the IFPA area. The Resources Inventory Branch and the Region may check the results of these analyses. The MOF will complete the statistical analysis in the Remainder of the TSA and combine the data with that in the IFPA area.

10.9 Roles and Responsibilities

Ministry of Forests

The MOF will:

- Select the sample polygons (Resources Inventory Branch).
- Select sample locations within polygons (Vancouver Forest region).
- Prepare all sample packages (Vancouver Forest Region)
- Mentor NVAF crews (Resources Inventory Branch).
- Conduct NVAF quality assurance (Resources Inventory Branch)
- Conduct sample cluster quality assurance (Vancouver Forest Region)
- Check data after initial compilation (Vancouver Forest Region).
- Validate and compile data (Resources Inventory Branch).
- Provide attribute files and minimum standards for statistical analysis (Resources Inventory Branch).
- Prepare and sign-off Standards Agreement and Schedule A (Agreement between Interfor and the MOF Vancouver Regional Office)(Vancouver Forest Region).

Interfor

Interfor will:

- Liaise with the MOF to ensure IFPA and TSA goals are met.
- Award fieldwork contracts for the IPFA and the TSA.

J.S. Thrower & Associates

J.S. Thrower & Assoc. will, on behalf of Interfor:

- Prepare Sampling Plan for entire TSA and the IFPA area.
- Provide mentor for field crews at the start of fieldwork.
- Coordinate project activities.
- Liaise with the MOF.
- Monitor and communicate project progress to MOF and Interfor.
- Ensure all contractors are qualified and certified; and tender and manage fieldwork contracts.

- Assess access and coordinate the use of helicopters.
- Monitor the budget.
- Identify access routes and potential tie points.
- Ensure sample packages in the IFPA area and TSA are assembled and complete.
- Oversee ground sampling activities.
- Ensure quality assurance (QA) is complete.
- Assist in coordinating technical expertise where required.
- Ensure the data submitted to MOF is clean.

Field work contractors

- Complete field sampling.
- Conduct internal quality control.
- Enter the sample data.

Check-cruiser

- Complete QA work for 10% of the VRI samples, and issue quality certificates.
- Complete call grading/net factoring of the NVAF samples.
- Enter the sample data.
- Prepare the QA report.

11. APPENDIX A

MAP SHEET NUMBERS FOR THE FRASER TSA DATABASE SAMPLED

092G009	092G058	092H015	092H065
092G010	092G059	092H016	092H071
092G018	092G060	092H017	092H072
092G019	092G065	092H021	092H073
092G020	092G066	092H022	092H074
092G026	092G067	092H023	092H075
092G027	092G068	092H024	092H081
092G028	092G069	092H025	092H082
092G029	092G070	092H026	092H083
092G030	092G076	092H031	092H084
092G033	092G077	092H032	092H085
092G034	092G078	092H033	092H091
092G035	092G079	092H034	092H092
092G036	092G080	092H035	092H093
092G037	092G090	092H041	092H094
092G038	092G099	092H042	092I001
092G039	092G100	092H043	092I002
092G040	092H001	092H044	092I003
092G044	092H002	092H045	092I004
092G045	092H003	092H051	092I013
092G046	092H004	092H052	092I014
092G047	092H005	092H053	092J009
092G048	092H006	092H054	092J010
092G049	092H007	092H055	092J019
092G050	092H011	092H061	092J020
092G055	092H012	092H062	
092G056	092H013	092H063	
092G057	092H014	092H064	

12. APPENDIX B

LIST OF SAMPLE POLYGONS IN THE IFPA AREA

PROJ_NO	SAMPLE	BATCH	MAP_NO	POLY_NO
Batch 1(16 samples)				
0302	1	1	092H023	595
0302	2	1	092H043	1124
0302	3	1	092H043	993
0302	4	1	092H014	371
0302	5	1	092H014	1188
0302	6	1	092H054	794
0302	7	1	092H004	209
0302	8	1	092H053	699
0302	9	1	092H014	1297
0302	10	1	092H053	649
0302	11	1	092H054	265
0302	12	1	092H024	456
0302	13	1	092H033	210
0302	14	1	092H033	204
0302	15	1	092H013	1260
0302	16	1	092H033	223

Batch 2 (16 samples)				
0302	17	2	092H032	67
0302	18	2	092H024	696
0302	19	2	092H053	232
0302	20	2	092H023	1319
0302	21	2	092H043	1256
0302	22	2	092H053	431
0302	23	2	092H044	954
0302	24	2	092H023	1187
0302	25	2	092H023	602
0302	26	2	092H033	90
0302	27	2	092H014	545
0302	28	2	092H023	1426
0302	29	2	092H054	1566
0302	30	2	092H053	380
0302	31	2	092H004	662

PROJ_NO	SAMPLE	BATCH	MAP_NO	POLY_NO
0302	32	2	092H014	906
Batch 3 (18 samples)				
0302	33	3	092H033	447
0302	34	3	092H013	1422
0302	35	3	092H043	82
0302	36	3	092H023	379
0302	37	3	092H023	760
0302	38	3	092H022	330
0302	39	3	092H043	385
0302	40	3	092H033	508
0302	41	3	092H043	383
0302	42	3	092H024	662
0302	43	3	092H053	835
0302	44	3	092H014	399
0302	45	3	092H054	1167
0302	46	3	092H033	650
0302	47	3	092H044	517
0302	48	3	092H054	1670
0302	49	3	092H054	1689
0302	50	3	092H043	1365

13. APPENDIX C

LIST OF SAMPLE POLYGONS IN THE REMAINING (NON-IFPA) AREA OF TSA

PROJ_NO	SAMPLE	BATCH	MAP_NO	POLY_NO
Batch 1 (15 samples)				
0301	1	1	092H093	519
0301	2	1	092G030	307
0301	3	1	092H093	629
0301	4	1	092G036	668
0301	5	1	092G030	627
0301	6	1	092G030	1152
0301	7	1	092G050	205
0301	8	1	092H071	109
0301	9	1	092H061	757
0301	10	1	092H071	122
0301	11	1	092H002	307
0301	12	1	092H081	326
0301	13	1	092H013	433
0301	14	1	092G080	342
0301	15	1	092G018	63

Batch 2 (15 samples)				
0301	16	2	092H021	555
0301	17	2	092G040	778
0301	18	2	092H074	678
0301	19	2	092G058	1261
0301	20	2	092H041	481
0301	21	2	092G030	147
0301	22	2	092G050	683
0301	23	2	092H093	1261
0301	24	2	092H043	534
0301	25	2	092H002	499
0301	26	2	092H073	1505
0301	27	2	092H042	884
0301	28	2	092H055	150
0301	29	2	092H001	577
0301	30	2	092H033	1033

PROJ_NO	SAMPLE	BATCH	MAP_NO	POLY_NO
Batch 3 (15 samples)				
0301	31	3	092H031	674
0301	32	3	092G029	123
0301	33	3	092G050	292
0301	34	3	092H031	910
0301	35	3	092H052	332
0301	36	3	092H031	260
0301	37	3	092G040	532
0301	38	3	092H024	1379
0301	39	3	092H002	526
0301	40	3	092H073	1771
0301	41	3	092H042	655
0301	42	3	092H044	567
0301	43	3	092H044	518
0301	44	3	092G027	545
0301	45	3	092H082	786

Batch 4 (15 samples)

0301	46	4	092G019	234
0301	47	4	092G059	506
0301	48	4	092H062	43
0301	49	4	092H012	315
0301	50	4	092G039	368
0301	51	4	092G049	1314
0301	52	4	092H041	298
0301	53	4	092H034	921
0301	54	4	092G100	72
0301	55	4	092H073	1078
0301	56	4	092H091	1992
0301	57	4	092H034	1320
0301	58	4	092G050	1065
0301	59	4	092H071	411
0301	60	4	092H062	450

Batch 5 (15 samples)

0301	61	5	092H022	271
0301	62	5	092G069	1600
0301	63	5	092H031	495
0301	64	5	092H042	807

PROJ_NO	SAMPLE	BATCH	MAP_NO	POLY_NO
0301	65	5	092H021	456
0301	66	5	092H031	123
0301	67	5	092G060	1252
0301	68	5	092G050	310
0301	69	5	092H051	633
0301	70	5	092H001	958
0301	71	5	092G059	793
0301	72	5	092H042	470
0301	73	5	092H092	1276
0301	74	5	092H072	1030
0301	75	5	092G009	200

Batch 6 (12 samples)

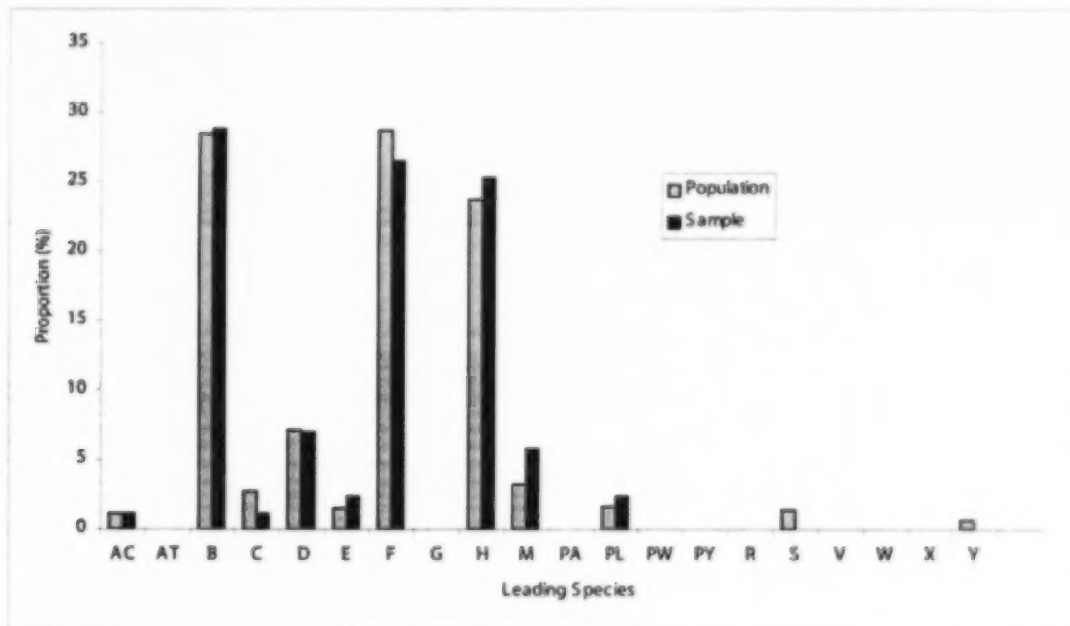
0301	76	6	092G009	71
0301	77	6	092G050	861
0301	78	6	092H003	906
0301	79	6	092G067	520
0301	80	6	092H094	568
0301	81	6	092G100	1073
0301	82	6	092H094	242
0301	83	6	092H034	625
0301	84	6	092G039	412
0301	85	6	092H052	897
0301	86	6	092I002	981
0301	87	6	092H035	373

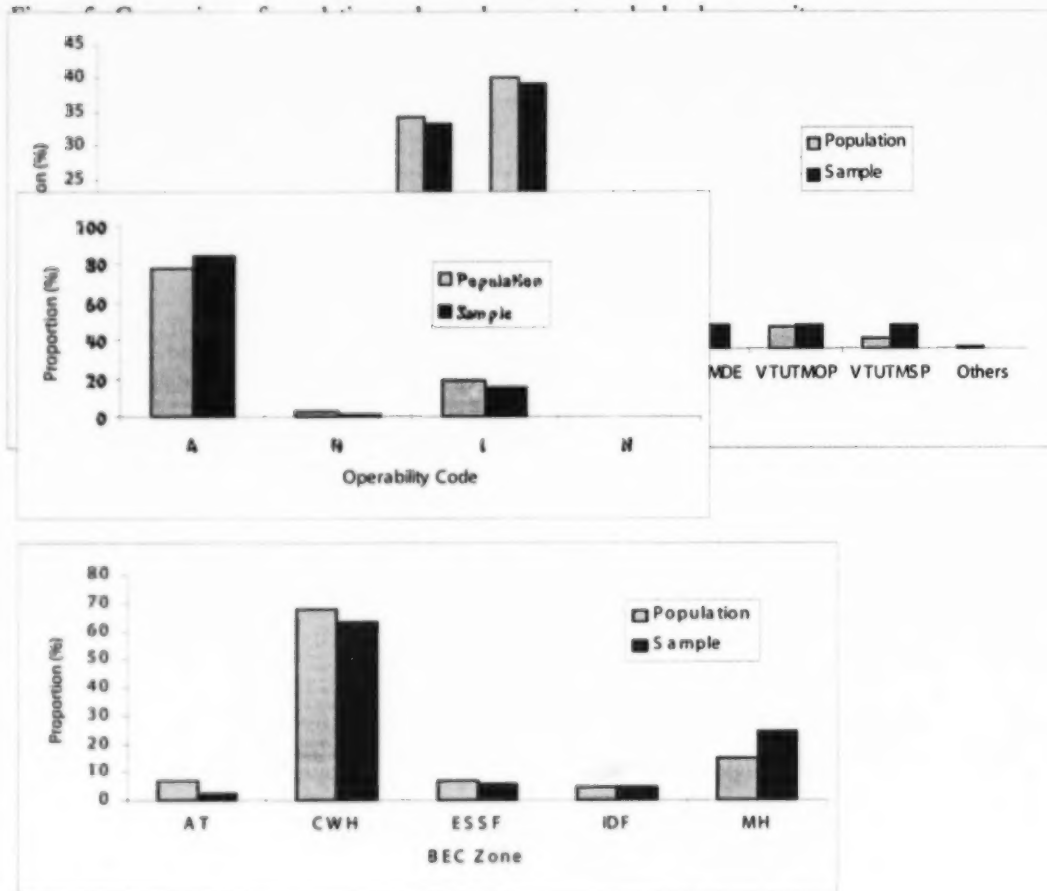
14. APPENDIX D

COMPARISON BETWEEN POPULATION AND THE SAMPLE POLYGONS IN THE FRASER TSA

15.

The following four graphs depict the comparisons for the entire TSA (combined IFPA Area and Remaining Area of TSA) between population and sample percentages by Leading species, BC Landcover Classification scheme (BCLCS), Biogeoclimatic zone (BEC), and Operability. The population values are area percentages, and the sample values are proportions of number of samples. The graphs suggest that the selected sample (Appendices B and C) is representative of the entire Vegetated Treed TSA target population. (Similar observations were made when comparisons were made separately for the IFPA Area and for the Remaining Area; these graphs are, however, not shown here.)





16. APPENDIX E

EXAMPLE: IMPACT OF ADDING SAMPLES IN THE IFPA AREA

We outline a simple example to illustrate one way to compile the inventory in the Fraser TSA. The purpose of this example is to demonstrate that adding samples to the Hope IFPA area within the Fraser TSA and compiling the IFPA area separately will not affect the estimates of volume in the remainder of the TSA. The example compilation involves 3 steps:³⁶

1. Suppose we install an initial sample of 46 polygons over the entire TSA land base: 27 fall in the IFPA area and 19 in the Remaining Area.
2. Compile the inventory volumes separately for each area, and combine using the stratified sampling method (Table 4).

Table 4. Illustration of inventory compilation before adding samples to IFPA Area.

Target Population	Sample size	Average volume (m ³ /ha)	Area weights
Remaining Area	19	455.2	0.413
IFPA area	27	403.2	0.587
<i>Total (weighted)</i>	<i>46</i>	<i>424.6</i>	

1. Add a second batch of 100 samples in the IFPA area, and recompile the inventory separately for each area, and combine again using the stratified sampling method (Table 5).

Table 5. Illustration of inventory compilation *after* adding samples to IFPA Area.

Target Population	Sample size	Average volume (m ³ /ha)	Area weights*
Remaining Area	19	455.2	0.413
IFPA Area	127	451.9	0.587
<i>Total (weighted)</i>	<i>146</i>	<i>453.3</i>	

* Area weights do not change, since strata sizes are still the same.

³⁶ The volumes used in this example are based on the Fraser TSA inventory audit where, for illustration purposes, the TSA Operable landbase corresponds to the IFPA area and the Inoperable area corresponds to the remainder of the TSA

In this example, we observe that after adding samples in the IFPA area, the volume/ha in the Remaining area is unchanged, while that in the IFPA area and the new total volume have gone up.

Chilliwack Forest District

Documentation of Analysis for Vegetation Resources Inventory Statistical Adjustment

ADDENDUM

**PREPARED BY:
MINISTRY OF SUSTAINABLE RESOURCE MANAGEMENT
RESOURCES INVENTORY DEPARTMENT
TERRESTRIAL INFORMATION BRANCH**

MARCH 2003

1. BACKGROUND

Adjustment factors (age, height and volume¹) for the Chilliwack Forest District were provided in the spring of 2002 and have been documented in the report "Chilliwack Forest District VRI Analysis Report" available on the Ministry of Sustainable Resource Management (MSRM) website². These adjustment factors were produced for the vegetated treed (VT) population greater than 29 years of age and were based on 11 analysis strata defined by geographic area, operability and leading species group as follows:

- Chilliwack River Landscape Unit (CRLU)
- Hope Innovative Forestry Practices Agreement area (IFPA), inoperable
- "TSA", inoperable (where "TSA" is the non-IFPA, non-CRLU portion of the Fraser TSA)
- IFPA, operable; balsam, spruce or pine leading
- IFPA, operable; fir leading
- IFPA, operable; hemlock or cedar leading
- IFPA, operable; other species leading
- "TSA", operable; balsam, spruce or pine leading
- "TSA", operable; fir leading
- "TSA", operable; hemlock or cedar leading
- "TSA", operable; other species leading.

At the request of the Ministry of Forests (MOF) Timber Supply Branch, the VRI data was re-examined to investigate further age sub-stratification of the adjustment factors in December 2002 and early 2003. This analysis was guided by input from MOF and MSRM staff in the Chilliwack Forest District, Timber Supply Branch, and Terrestrial Information Branch.

As a result of this analysis, the operable portions of the IFPA and "TSA" were further sub-stratified into two age groups: 30 – 59 years and ≥60 years. For the 30 – 59 years group, there was no stratification by species. For the ≥60 years group, the original species stratification described above was maintained except in the operable portion of the IFPA where balsam, spruce, pine and hemlock, cedar were combined into one species group. In addition, the >29 years, inoperable portion of the "TSA" and the >29 years, inoperable portion of the IFPA were combined into a single stratum. The results of this analysis are provided in section below.

2. RESULTS

Height, age³ and volume adjustment factors for the Chilliwack Forest District, based on analysis carried out in early 2003⁴, are provided in Table 1. Note that the population of interest for this adjustment is all

¹ Volume adjustment factors were based on compiled volumes that were based on net factoring and NVAF. The compiled data was provided on November 15, 2001.

² http://srmwww.gov.bc.ca/tib/reports/invadreports/chilliwack_forest_district_vri_analysis_final.pdf

³ In this analysis, inventory ages and heights were re-projected to match the year of ground sampling. This resulted in some small changes to the height and age ratios compared with the previous analyses.

⁴ In this analysis, least squares regression and geometric mean regression were also examined as alternative adjustment methodology. These alternative techniques did not offer any advantages over the ratio-of-means approach in this unit.

vegetated treed (VT) polygons greater than 29 years of age in the Chilliwack Forest District. Ratios for the "Other" species group represent an "average" i.e. the ratio is based on an area weighted combined ratio estimate by species and missed/non-missed areas⁵.

The volume factors will produce adjusted volumes that represent an average "mixed utilization": 12.5cm+ utilization net dwb for polygons with inventory age ≤140 year and 17.5cm+ net dwb utilization for polygons with inventory age >140 years. This was the utilization for the Phase II volumes used in the adjustment factor derivation. The Phase II volumes were based on net factoring with NVAF and were compiled in November of 2001. Volume adjustment ratios are to be applied to "attribute-adjusted" inventory volumes at a 17.5cm+ dbh net dwb utilization. More detailed results, showing means and areas for missed area and non-missed area samples within each sub-stratum can be found in Appendix A.

Table 1: Adjustment factors based on further age stratification in "TSA"/IFPA operable; "TSA" & IFPA inoperable are combined, for VT polygons >29 years.

Strata	Adjustment factors		
	Height ratio (n)	Age ratio (n)	NVAF Volume ratio (n)
CRLU >29 yrs	0.937 (21)	0.858 (21)	0.930 (26)
"TSA" inoperable & IFPA inoperable; >29 yrs	0.847 (23)	0.699 (22)	1.070 (28)
"TSA" operable 30-59 yrs	0.959 (13)	0.962 (13)	1.336 (14)
IFPA operable 30-59 yrs	1.125 (9)	1.240 (9)	1.059 (11)
"TSA" operable >59 yrs			
Balsam, Spruce, Pine	0.879 (13)	0.835 (13)	1.025 (14)
Fir	0.975 (11)	0.801 (10)	0.984 (12)
Hemlock, Cedar	0.862 (15)	0.948 (10)	0.953 (17)
Other	0.889 (ave)	0.854 (ave)	1.011 (46)
IFPA operable >59 yrs			
Fir	0.934 (10)	0.895 (10)	1.068 (10)
BSP & HC	0.959 (15)	0.890 (16)	1.027 (17)
Other spp	0.951 (ave)	0.891 (ave)	1.044 (27)

⁵ Refer to original Chilliwack Forest District VRI Analysis Report.

3. APPENDIX A: DETAILED RESULTS

Table A1: Means and adjustment ratios by strata for height and age, VT >29 years.

Strata	Substratum for weighting	Area (ha)	Height Adjustment			Age Adjustment				
			n	Mean ground height	Mean inventory height	Ratio	n	Mean ground age	Mean inventory age	Ratio
CRLU >29 years	na		21	23.49	25.07	0.937	21	66.257	77.24	0.858
"TSA" inoperable and IFPA inoperable; >29 years	"TSA" non-missed area	179289.49	6	21.97	26.53		5	125.58	189.4	
	"TSA" missed area	12098.721	1	18.40	15.30	0.847	1	164.4	154	0.699
	"IFPA" non-missed area	42157.82	15	20.73	23.91		15	145.46	191.27	
	"IFPA" missed area	716.373	1	10.90	7.20		1	83.1	34	
"TSA" operable 30-59 years	non-missed area	68147.059	13	18.25	19.04	0.959	13	44.18	45.92	0.962
	missed area	2149.324	0				0			
IFPA operable 30-59 years	non-missed area	15929.531	8	16.95	15.29	1.125	8	53.58	42.88	1.240
	missed area	1127.534	1	27.50	21.20		1	61	54	
"TSA" operable >59 years Balsam, pine, spruce	non-missed area	64288.597	11	27.43	31.25	0.879	11	195.74	245.36	0.835
	missed area	11207.188	2	22.95	25.85		3	189.17	164	
Fir	non-missed area	71740.818	10	30.29	29.94	0.975	10	125.66	156.8	0.801
	missed area	6703.452	1	16.10	28.60		0			
Hemlock, cedar	non-missed area	72073.849	15	30.73	35.63	0.862	10	255.48	269.4	0.948
	missed area	2427.048	0				0			
Other (decid)	non-missed area	29336.693	2	21.30	28.05	0.889*	2	52.8	98.5	0.854*
	missed area	24.682	0				0			
IFPA operable >59 years	non-missed area	13274.604	9	25.07	25.82	0.934	9	102.17	118.89	0.895
	missed area	1548.214	1	25.60	36.20		1	200.5	184	
BSP & HC	non-missed area	24350.364	15	28.99	30.23	0.959	16	197.17	221.62	0.890
	missed area	500.793	0				0			
Other spp	non-missed area	1392.201	0			0.851*	0			0.891*
	missed area	0	0				0			

* Ratios for "Other species" stratum is based on area-weighted average of all samples in all strata

Table A2: Means and ratios by strata for volume adjustment and volume impact, VT >29 years.

Strata	Substratum for weighting	Area (ha)	NVAF Volume Adjustment Factor (based on "mixed" utilization for ground vol/ha)				NVAF Volume Impact			
			n	Mean ground vol/ha	Mean attrib-adj'd inv vol/ha @17.5cm+	Ratio	n	Mean ground vol/ha	Mean inventory vol/ha @17.5cm+	Ratio
CRLU >29 years			26	272.77	293.24	0.93	26	272.77	333.8	0.817
"TSA" inoperable and IFPA inoperable: >29 years	"TSA" non-missed area	179289.49	10	208.7	194.98		10	208.7	247.01	
	"TSA" missed area	12098.721	1	330.75	88.8	1.07	1	330.75	151.7	0.831
	"IFPA" non-missed area	42157.82	16	214.09	264.431		16	214.09	346.63	
	"IFPA" missed area	716.373	1	39.28	0		1	39.28	0	
"TSA" operable 30-59 years	non-missed area	68147.059	14	191.16	143.05	1.336	14	191.16	157.31	1.215
	missed area	2149.324	0							
IFPA operable 30-59 years	non-missed area	15929.531	10	145.44	145.56	1.059	10	145.44	101.15	1.528
	missed area	1127.534	1	253.18	123.4		1	253.18	81.2	
"TSA" operable >59 years Balsam, pine, spruce	non-missed area	64288.597	11	446.37	431.09	1.025	11	446.37	508.94	0.866
	missed area	11207.188	3	195.13	216.1		3	195.13	263.07	
Fir	non-missed area	71740.818	11	451.31	428.59	0.984	11	451.31	444.89	0.946
	missed area	6703.452	1	36.72	360.2		1	36.72	388	
Hemlock, cedar	non-missed area	72073.849	17	479.67	503.27	0.953	17	479.67	611.86	0.784
	missed area	2427.048	0							
Other (decid)	non-missed area	29338.693	3	261.34	170.5	1.011*	3	261.34	210.87	0.878
	missed area	24.682	0							
IFPA operable >59 years	non-missed area	13274.604	9	357.26	303.4	1.068	9	357.26	343.9	0.953
	missed area	1548.214	1	262.6	511.2		1	262.6	543	
BSP & HC	non-missed area	24350.364	17	505.131	491.947	1.027	17	505.131	516.982	0.977
	missed area	500.793	0				0			
Other spp	non-missed area	1392.201	0			1.044*	0			0.974*
	missed area	0	0				0			

* Ratios for "Other species" stratum is based on area-weighted average of all samples in all strata



